AMENDMENT TO THE SPECIFICATION

[Para 2] The method of the present invention belongs to area of nondestructive testing (NDT). Contrary to common practice this method implies completely passive monitoring technique. Most[[ly]] modern NDT technologies employ active methods of interaction with the test subject that employ external sources of test substances or other distortions. The most common of them are: Visual inspection; Liquid penetrant; Acoustic emission; Eddy current; Ultrasonics; Radiography; Magnetic particles; Acousto-photonic.

[Para 6] Ultrasonics is based on active scan of a system using source of ultrasound waves. This technology has been mostly replaced by AE. One of the reasons for drop in its popularity is complexity of this technique that requires[[d]] considerable technical training and skills.

[Para 14] The method disclosed in the present invention does not rely on such events but instead determines structural integrity of the subject by testing its integral pattern of sensor's signals on compliance with a priory found pattern characteristics. The set of such characteristics can be established once or can be dynamically built[[d]] and/or adjusted continuously or periodically.

[Para 15] Another benefit of the method is its ability to use low cost sensors.[[,]] I[[i]]t can be so[[r]]lely based on the use of slow response low bandwidth acoustical, thermal, pressure, etc sensors.

[Para 23] Fig. 1 diagram shows time series of sensor data that is acquired (10) and a set of proposed characteristics (11) computed for them. In case of multiple time series these characteristics form proposed Integrity matrix (12). The subject of the test/monitoring at some moment has to be present at a state of known integrity (13). Example of such state is "normal operational" when it is known that the subject remains in desirable conditions. This state is called Valid state (13). In valid state the set of proposed characteristics and or proposed Integrity matrix are used to update Valid Characteristics (14) of the subject. When the state of the subject needs to be determined the subject is present in Unknown state (15). The state validation occurs by comparison (16) of the proposed characteristics and or Integrity matrix versus the Valid characteristics. When these two sets do[[es]] not match within imposed constraints, the Unknown state is treated as invalid and Integrity failure (17) processing begins.

[Para 24] Following mathematical worksheet illustrates mathematical approach for described method that can be employed to compute Integrity matrix in designs that employ multiple sources of sensors signal. To simplify its understanding some details are skipped. Steady state scenario uses the same approach that results in partitioned matrix or a collection of matrixes where each matrix is linked to individual state. It is assumed that current state of the subject is Valid. This assumption is tested if previously known valid state exists, or is taken by default if no prior data exists. It is also assumed that the length of time series that represent sensors signals is sufficient to average stochastic components in those signals.

LTI system defined by indefinitely dimensional space **G** of matrixes g_i

$\vec{s}(t) = g_i \otimes \vec{f_i}(t)$ (100)

, where $\vec{s}(t)$ is vector of sensor readings, $\vec{f_i}(t)$ is vector of unknown stimuli[[uses]], and $i \in [0, \infty)$ for complete functional space **P** of the stimuli[[uses]].

Space **P** is defined through complete set of locations and types of external and internal distort[s]ions applicable to the system. Functional space **K** superse[[e]]des **P** by addition of functional space of sensor readings: K = P ⋃ S .

Functional vectors in space K constructed as

$\vec{k} = \begin{pmatrix} s_0 \\ \vdots \\ s_n \\ f_0 \\ \vdots \end{pmatrix}$, where **n** is number of sensors attached to the system. The same system will remain LTI when considered in space **Q** of matrixes q_j

$\vec{s}(t) = q_j \otimes \vec{k_j}(t)$ (200)

Space of rectangular matrixes q_j has invariant square minor of rank **n** $q_j = |M_n \cdots|$

It can be found from equation 200 as

$\vec{s}(t) = M \otimes \vec{s_i}(t) + h_i \otimes \vec{f_i}(t) \Longrightarrow h_i \otimes \vec{f_i}(t) = \vec{0}$, and $M = \begin{pmatrix} 0 & m_1^0 & \cdots & m_n^0 \\ m_0^1 & 0 & & \vdots \\ \vdots & & \ddots & m_n^{n-1} \\ m_0^n & \cdots & m_{n-1}^n & 0 \end{pmatrix}$

[Para 27] Stateful transitions of the system result[[s]] in statistically significant clustering of coefficients of the matrix. This clustering is used to create separate partition in the matrix or in some cases separate version of said matrix associated with particular steady state.

[Para 28] Matrix mallows efficient solution in cases of multiple sensors. In case of single channel designs the convolution operator has limited use. More efficient approach for this case is a use of preset filters. Autocorrelation, self convolution in Fourier space, match-filtering are just some examples of such filters. The role of the filter is to discover nonrandom characteristics in plurality of sensor data sets. For one experienced in art of digital filters and signal processing it is obvious that plurality of standard algorithms can be used in this method, as well as custom filters can be constructed to suit[[e]] special design tasks.

[Para 30] In order to validate current integrity state of the subject its sensors need[[s]] to be pooled and a new set of characteristics and or matrix to be computed. Their values are compared versus all partitions of the characteristics sets and or the matrixes. If matching partition exists the current integrity state of the subject is valid, and newly polled datasets can be merged with matching partition.

[Para 31] For one experience<u>d</u> in the art of software development and signal processing it is obvious that variety of alternative algorithms can be chosen to implement disclosed idea. The method disclosed in this invention does not intend to limit this idea to one example

implementation and only serves as an example to illustrate the primary subject of the invention. It is also obvious that method can be optimized for various hardware implementations and can use sequential, parallel, incremental, recursive and plurality of other alternatives.

[Para 33] Perform initial profiling of the system that involves: 1) periodic or non-periodic acquisition of all sensor channels over some time period; 2) computation of structural Integrity matrix M and/or persistent Characteristics, standard sensor noise level and achievable detection speed. Detection speed or timing depends on multiple factors such as reliability and quality of sensors, average level of standard distortions and their types, physical properties of the system. Long timing indicates that structural integrity alert signal will be raised with significant delay after structural integrity of the system being affected. The term initial only indicates that the subject system is considered to be in the Valid state. The profiling can be performed at any time the state of the system is Valid.

[Para 38] Switch to alert mode and rise integrity degradation signal when current Characteristics do[[es]] not fit into allowable constrained functional space or any other constrains are violated. This mode can be reset manually or automatically and initial profiling of the system executed.

[Para 39] Fig. 2 shows schematic of basic node of the invented apparatus. A network of the nodes can form very sophisticated structural integrity monitoring systems. Component or

system 100 that needs to be monitored equipped with plurality of sensors 101 that linked with the apparatus 200 that formed by plurality of nodes. As an example thermal and acoustical sensors with optical transducers are shown. It was previously described, the types of sensors may vary as well as any number of redundant sensors can be used. Lower part of the picture shows these sensors connected through optical or electrical busses 102 to signal converter/amplifier 103 which transforms all sensor outputs to the same form. These signals are further converted into digital form by converter[[d]] 104, which may be integrated into processing module 105. Processing module 105 executes all methods and algorithms described in the previous sections and can be implemented as a digital microcontroller, DSP, generic processor, computer, optical computer or any other means capable of performing the method of the invention.

[Para 44] Profiling process is always treated as static stochastic process regardless of type of disturbances. This assumption is true even in the case when the process has[[ve]] multiple states. Each population P_n checked on presence of significantly separated clusters (35) using one of standard statistical approaches. In this example paired student T-test is employed to find the clusters. This process results in collection of P_n^c populations (36), where c-is identifier for specific state/cluster.

[Para 58] Nodes of type 110 do[[es]] not have capabilities to receive external sensor data due to limitation of their processor resources, they form tree-like network by means of hubs 111 that receive sensor data from several nodes and perform computation of sub-

system structural matrixes using the method of the invention, and monitor integrity of the system part that associated with linked nodes.

[Para 59] In some implementations nodes of type 110 do[[es]] not have processing capabilities and only capable of initial conditioning of the signals and transmitting their data to other node types.

[Para 63] Complex subjects or subjects with large geometrical/geographical dimensions may implement the method by means of communication through public or private information network. Processing nodes of type 111 or 112 may be employed to discover persistent signal Characteristics that associated with remotely located nodes. Examples of such implementations: bridges, stationary platforms, land masses. In case of land masses the some apparatuses of the invention may be placed on mountain ridge while others buried near a shore line. Nodes in mountain locations can be linked to public telephone network through cellular connections to nearest tower, while nodes on shore line can be directly connected to telephone lines. This way processing nodes can be located anywhere on earth. Violation of the persistent Characteristics in the pattern of the signals and invalidation of structural integrity in such system may be an indication of approaching landslide, earthquake, or some other major events.

[Para 67] It is obvious to one experienced in the art that the method and apparatuses of the invention can be implemented to provide NDT and malfunction monitoring for static

structures, vehicles, marine structures and marine vehicles, aircrafts, spacecrafts and space based structures, geological structures such as mines, gas deposits, oil deposits, large land masses, etc.

[Para 68] In some implementations the method can be used to report not only failure or degradation of structural and functional characteristics but also unusual usage events and/or patterns[[,]] that in some cases can also be used for security purposes. Example of such implementation can be acoustic sensor located inside the building that detects alteration in acoustic reverb of the room caused by open door at unusual daytime.